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IV.

Internal Anatomy of CORYDALUS CORNUTUS in its three Stages of Existence.

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(*With Two Plates.*)

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I. OF THE DIGESTIVE APPARATUS.

1. *In the Larva.*—The insect, being predaceous in habit, has a structure of the digestive apparatus in accordance with the nature of its food.

The alimentary canal is a little longer than the animal, in consequence of a single short convolution of the small intestine.

The mouth opens in an infundibuliform manner into a wide œsophagus, which latter extends backwards through the pro- and meso-thorax, gradually dilates, and forms between the meso- and meta-thorax the proventriculus.

The œsophagus is thick and strong, and presents distinctly to view three tunics: the external, a delicate, transparent, filamentous lamina; the central, a muscular lamina, composed principally of transverse fibres; and the internal, or mucous layer, which is thrown into six plicated, more or less regular longitudinal folds, extending its whole length.

The proventriculus is a strong gizzard, ovate in form, and gradually contracted at its posterior part, forming a tube narrower than the œsophagus which passes back into the abdominal cavity. It is only separated from the œsophagus by a change in structure. Its thickness generally is not greater than that of the œsophagus, but is strengthened by stout muscular columns, projecting in its length from the inner surface of the cavity. These columns are twelve in number, and are exceedingly regular in regard to position and form. Six of them are broad, and alternate with the other six, which are comparatively narrow. They may be considered as defining the cavity of the proventriculus. The broader columns are on a line with, and correspond to, the œsophageal folds. Each of them consists of two portions: an upper pyramidal, and a lower tile-like or flat por-

tion. The pyramidal portion of the broad columns has its base anterior; the apex is posterior, compressed laterally, and unattached to the surface of the cavity. Each of the free sides of this portion possesses an oblong space, covered by short and stiff hairs; the sides of the apex are also furnished with hairs, which are two or three times longer than the others. The flat portion of these columns is a muscular basis for the attachment of stomachal teeth. These teeth are composed of a hard, corneous substance, are broad and concave posteriorly, projecting in a pointed process at the anterior part of the concavity, and elongated forwards into a manubrium. The three alternate of these bodies are rather narrower than the others. The six intermediate columns are narrow and cochleariform, and only extend the length of the pyramidal portion of the broad columns. The columns, as well as the intermediate spaces, are covered by a moderately thick epithelium. The posterior tubular portion of the proventriculus presents a number of longitudinal folds internally, and opens into the ventriculus.

The ventriculus is a quadrilateral receptacle, apparently formed by the apposition of four cylinders which anteriorly diverge slightly, and form as many cœcal pouches lying along the posterior proventriculus. The walls of this cavity are thin, and the internal surface is smooth. It contained a fluid matter of a whitish, granular appearance.

At the commencement of the fifth abdominal segment the ventriculus opens into the large intestine. The latter is separated from the former by a contraction, at which point the biliary tubes open. Commencing somewhat dilated, the large intestine then contracts, and forms a short convolution forward, then gradually dilates, and proceeds towards the anus, before reaching which it becomes gradually contracted again. The large intestine is thin, corrugated, and dilatable. Salivary glands do not exist.

The biliary tubes are eight in number, long, convoluted, and closely applied to the sides of the large intestine. They open at the contraction separating the ventriculus from the large intestine.

2. *In the Pupa.* — The œsophagus is narrower than in the larva, is cylindrical, and pretty uniform, and extends backwards as far as the commencement of the metathorax, where it opens into what corresponds to the ventriculus of the larva. It does not present the internal folded appearance of the larva, and the apparatus of the proventriculus of the latter has entirely disappeared in this stage; but as a substitute, we find a crop within the metathorax opening into one side of the œsophagus. This crop resembles the sucking stomach of many Lepidoptera, is simple, and lies folded upon the œsophagus. It was usually found empty.

The ventriculus is capacious, and extends from the termination of the œsophagus nearly to the posterior part of the third abdominal segment. It is of an elongated ovate

form, the narrow end being posterior, and bulges a little more on one side than upon the other. Passing off from it anteriorly are four cœca, surrounding the œsophagus, and corresponding to those formed by the apparent division of the ventriculus in the larva; but they are double the length, and different in form. They are somewhat sacculated; the two dorsal ones are comparatively narrow and pointed; the other two have a rounded and dilated extremity. In structure the ventriculus of the pupa is stronger than that of the larva, its muscular tunic being better developed. The cœca are thinner than the ventriculus. Both of the latter were filled with a white, semifluid substance. The large intestine differs slightly from that of the larva, except that it is more abruptly dilated about its lower third. The biliary tubes have the same character and relations as in the larva.

3. *Imago*. — The œsophagus in the imago has become much elongated; commencing with the same diameter as in the pupa, it very gradually widens, and within the abdomen dilates into a spacious proventriculus, which extends as far back as the fifth abdominal segment. The form of the œsophagus and proventriculus resembles that of a long-necked Florence flask. From the posterior part of the proventriculus, on its dorsal aspect, there projects a short cœcum, which appears to be the remains of the crop of the pupa. In structure the œsophagus and proventriculus are thin, and were generally found much distended with air. The proventriculus joins the ventriculus by a short, narrow tube.

The ventriculus presents but little variation from that of the pupa; it is in a more contracted state, and consequently is fusiform in shape, and, from the lengthened œsophagus, is placed more posteriorly in the abdomen. The cœca lose the sacculated appearance, are all obtuse at the extremity, and are applied to the sides of the proventriculus.

The large intestine presents a larger convolution than in either of the other stages, is very rugous, the rugæ disappearing by inflation; and it abruptly dilates into an oval or fusiform cœcum in its lower third, which latter opens into the rectum.

The cœcum is moderately thick and strong, and has developed upon it a double row of glands. Each row, commencing at the posterior part of the cœcum on its dorsal aspect corresponding to each side of the rectum, proceeds forwards to the front of the cœcum and turns down to its ventral surface, and then continues backwards to a point corresponding to their commencement superiorly. The glands are oval in form, white, and placed at pretty uniform distances from each other, beneath the lining membrane of the cœcum and resting upon its muscular and outer tunic. In structure they are composed of a layer of simple organic nucleated cells. The cœcum contained the same substance which in the pupa was found in the ventriculus. The rectum comes off from the cœcum opposite the posterior part of the antepenultimate abdominal segment, and proceeds as a narrow canal to the anus. The biliary tubes are the same as in the other stages.

4. *Comparison of the Changes which take place in the three Stages.* — The comparatively wide œsophagus and proventriculus of the larva, which extend as far back as the third abdominal segment, we find contracted in the pupa and shortened to the posterior part of the mesothorax; the proventriculus with its apparatus of stomachal teeth has disappeared, and a small crop exists in its place, whilst in the imago we find the œsophagus again lengthened, still contracted at its commencement, but gradually dilating as it passes backwards, until it finally forms a capacious proventriculus, which, with the œsophagus, extends as far back as the fifth abdominal segment. The proventriculus of the imago has no return of the teeth of the larva, is thin in its walls, and has a small cœcum posteriorly, which is apparently the remains of the crop of the pupa. The columnar ventriculus of the larva, with its short anterior cœca, we find becoming converted into the elongated cœca of a newly developed fusiform ventriculus of the pupa; and in the imago we find the ventriculus contracted and the cœca somewhat changed in form. The large intestine shows but little change in passing from the larva to the pupa, but in the imago we find a cœcum, and numerous glands formed upon it. Within the posterior abdominal segment on the ventral aspect of the terminal portion of the large intestine, in all the stages, there exists an irregularly ovoidal sac, which contains a greenish viscid fluid. The exit of this sac, which is probably urinary, is at the edge of the anal orifice.

II. GENERATIVE APPARATUS.

In the larva the organs of reproduction exist in a very rudimentary state. The ovaries and testes have the same appearance, being elongated-ellipsoidal in form, composed of transverse fibres or indistinct tubules joining a common tube, and containing round bodies or organic cellules undistinguishable in any of the individuals examined. They are situated one upon each side of the small intestine, and from their posterior part proceeds a tube which joins its fellow beneath the urinary sac.

In the pupa the apparatus has become much more developed. The testes of the male have become much increased in size, and elongated as far forwards as the meta-thorax. The tubuli seminiferi are short tubes transversely situated, and all converging to the vas deferens. They contain spermatozoa in various stages of development.

The ovary of the female has also increased in length, though not to such an extent as the testicle, but has gained upon the latter in breadth from the lengthening of the ovigerous tubules. The ovarian tubules contain numerous ova in an immature condition, and sufficiently transparent within the tubuli to render their vitellus visible. In the male imago the testes have reached their highest point of development. They do not differ much in appearance from those of the pupa, excepting that in the individual particularly examined they were rather shorter. The tubuli appear more engorged, and contain per-

fectly formed spermatozoa. The vasa deferentia converge and join beneath the urinary sac to form a short ductus ejaculatorius, which latter terminates by an orifice at the extremity of an insignificant papilla, the only trace of a penis, existing upon the ventral surface in the interspace between the penultimate and last abdominal segment.

Attached to the last abdominal segment are four articulated appendages, which appear to have for their purpose the retaining hold of the female in coitu. In the female the ovaries are large, about two thirds the length of the testicle of the male, but three times as broad, and thicker. Each ovary consists of numerous ovigerous tubes, transversely arranged, commencing in fine points and gradually dilating to their termination in the oviduct. The tubes are held together, as well as the ovary in its position, by the numerous ramified tracheæ. Each ovarian tube contains ova in various stages of development, from a mere point at their commencement to two lines in length at their termination. There are generally from four to five ova matured, or nearly so, in each tube.

The mature ovum is about two lines in length and elongated-oval in shape.

The oviduct at its commencement forms the base of the ovigerous tubes, the opposite wall to the openings of which is thin and transparent. It becomes contracted at the posterior part of the ovary into a tube, which, passing backwards a few lines, joins its fellow to form a common tube, about a line in length, terminating in the vagina.

The vagina lies beneath the urinary sac, within the penultimate abdominal segment. It is a short, rounded receptacle, ending in a perforated papilla, rather longer than that of the male, between the ventral plates of the last and penultimate abdominal segments. From the foregoing description of the genitalia it is seen there is no true intromittent organ in the male, and almost no receptacle for such an organ in the female. I think it probable that the papilla, terminating the generative organs in both sexes, are applied together in coitu, whilst the female is retained in position by the abdominal appendages or claspers of the male.

III. NERVOUS SYSTEM.

The number of centres or ganglia, in correspondence with the number of free movable segments of the body, remains the same throughout the three stages of existence. The ganglia, as is usually the case in the Neuroptera, are well developed or large in size, and, in correspondence with the activity of the animal, give off numerous nerves.

1. *Particular Description in the Imago.* — The cerebrum, with its lateral productions, the optic nerves, forms a cylinder extending between the eyes and presenting four swellings. From its upper surface pass off three nerves to the simple eyes; anteriorly, the antennal nerves and the arched commissures to the frontal ganglion; and inferiorly, the cerebro-cerebellar commissures.

The cerebellum, or first ventral ganglion, is situated within the head, just posteriorly to the cerebrum, beneath the œsophagus. It is large, cordate in form, and gives off anterior branches to the mandibles, maxillæ, and antennæ, and posteriorly the prothoracic commissures to the prothoracic ganglion. The frontal ganglion is large and triangular. It gives off anteriorly two branches to the labrum, several minute branches laterally, and posteriorly a single trunk, which, passing beneath the cerebrum, is applied to the œsophagus, to which it sends off numerous minute branches, and is finally lost in it.

Two small respiratory ganglia also exist upon each side of the œsophagus, connected together by a short commissure and with the cerebrum by means of a similar commissure.

The ventral chain consists of eleven ganglia, excluding the first or cerebellum; three thoracic and eight abdominal.

The thoracic ganglia are considerably larger than those of the abdomen, are hexagonal in outline, and present an elliptical longitudinal swelling on each side of their middle line. The commissures connecting them are at first widely divergent, and then convergent so as to leave wide elliptical spaces between them. The first thoracic or the prothoracic ganglion is situated at the posterior part of the prothorax, and gives off laterally branches to the muscles which occupy the prothorax and a large branch to the first pair of legs. The second thoracic or the mesothoracic ganglion is situated just behind the centre of the mesothorax, and is the largest of the thoracic ganglia. It gives off laterally nerves to the first pair of wings, three branches to the muscles occupying the cavity of the mesothorax, and a large branch to the second pair of legs. The third thoracic or the metathoracic ganglion is situated very nearly in the centre of the metathorax, and is a very little smaller than the prothoracic ganglion. It gives off laterally a large nerve to the second pair of wings, three nerves to the muscles within the metathorax, and a large branch to the posterior pair of legs.

The abdominal ganglia are small trapezoidal knots, and, with the exception of the first and last, are placed at the commencement of their respective abdominal segments; the first being situated near the centre of the first abdominal segment, the last in the posterior part of the same segment which contains the one immediately preceding it. They are of nearly uniform size, and, with the exception of the last one, send off six nerves on each side to be distributed to the parts within the corresponding segment. The last ventral ganglion supplies the eighth and ninth abdominal segments.

In the larva, as in other Neuroptera, several simple eyes are substituted for the compound eye. In this insect they are six in number, and situated so as to look laterally and forward. The cornea is convex externally, and internally projects into the eye in the form of a cone with a rounded apex, which arrangement supplies the deficiency of a crystalline lens. The cone is not distinct from the cornea, and both are formed of thin

and transparent superimposed laminæ. The optic nerve, on reaching the base of the simple eyes, sends off as many cylinders, each of which passes outwardly to meet a corresponding projecting cornea. Each cylinder of the optic nerve and the inner projecting part of the cornea form a cylinder surrounded by the membrana choroidea, which latter passes a short distance between the nerve and cornea, forming a sort of iris.

EXPLANATION OF THE FIGURES.

PLATE II. — Principally exhibits the digestive apparatus of *Corydalus cornutus*.

Fig. 1. Represents the digestive apparatus of the larva, magnified two diameters: — *a.* œsophagus; *b.* proventriculus; *c.* ventriculus; *d.* large intestine; *e.* biliary vessels; *f.* urinary sac; *g.* testicle or ovary.

Fig. 2. The digestive apparatus of the pupa (male), magnified two diameters: — *a.* œsophagus; *b.* crop or proventriculus; *c.* ventriculus; *d.* cœca of ventriculus; *e.* large intestine; *f.* biliary vessels; *g.* urinary sac; *h.* testicle; *i.* vas deferens.

Fig. 3. The organs of digestion of the imago *in situ*, magnified two diameters: — *a.* œsophagus; *b.* proventriculus; *c.* cœca of the ventriculus; *d.* large intestine; *e.* cœcum of the large intestine, much distended and exhibiting its two rows of glands; *f.* rectum; *g.* urinary sac; *h.* main tracheal trunk, dividing into two large branches passing to the thorax and head; *i.* dorsal vessel.

Fig. 4. The lower portion of the alimentary canal of the imago, dissected out, magnified two diameters: — *a.* proventriculus; *b.* cœcum of proventriculus; *c.* ventriculus; *d.* cœca of the ventriculus; *e.* large intestine; *f.* cœcum; *g.* rectum; *h.* biliary vessels turned forwards; *i.* urinary sac.

Fig. 5. The same as fig. 4, from another individual, in which the parts were more contracted.

Fig. 6. The proventriculus of the larva laid open to its inner surface, magnified: — *a.* folds of the mucous membrane of the lower part of the œsophagus; *b.* muscular columns of the proventriculus; *c.* stomachal teeth.

Fig. 7. Front view of one of the muscular columns and teeth of the proventriculus, highly magnified.

Fig. 8. Side view of fig. 7.

Plate III. — Principally represents the nervous system and generative apparatus of *Corydalus cornutus*.

Fig. 1. The nervous system of the imago, magnified three diameters: — *a.* cerebrum; *b.* cerebellum; *c.* the three thoracic ganglia; *d.* abdominal ganglia.

Fig. 2. Two fragments of the eye of the larva, highly magnified, exhibiting the internal appearance of the conical projecting cornules.

Fig. 3. A longitudinal section of a cornule, highly magnified and exhibiting its laminated structure.

Fig. 4. An ideal section of one of the simple eyes of the larva, presenting the cornule projecting inwards, *a*; the optic nerve outwards, *b*; and the choroidea folding around the projecting portions, *c*.

Fig. 5. Testes of imago, magnified two diameters.

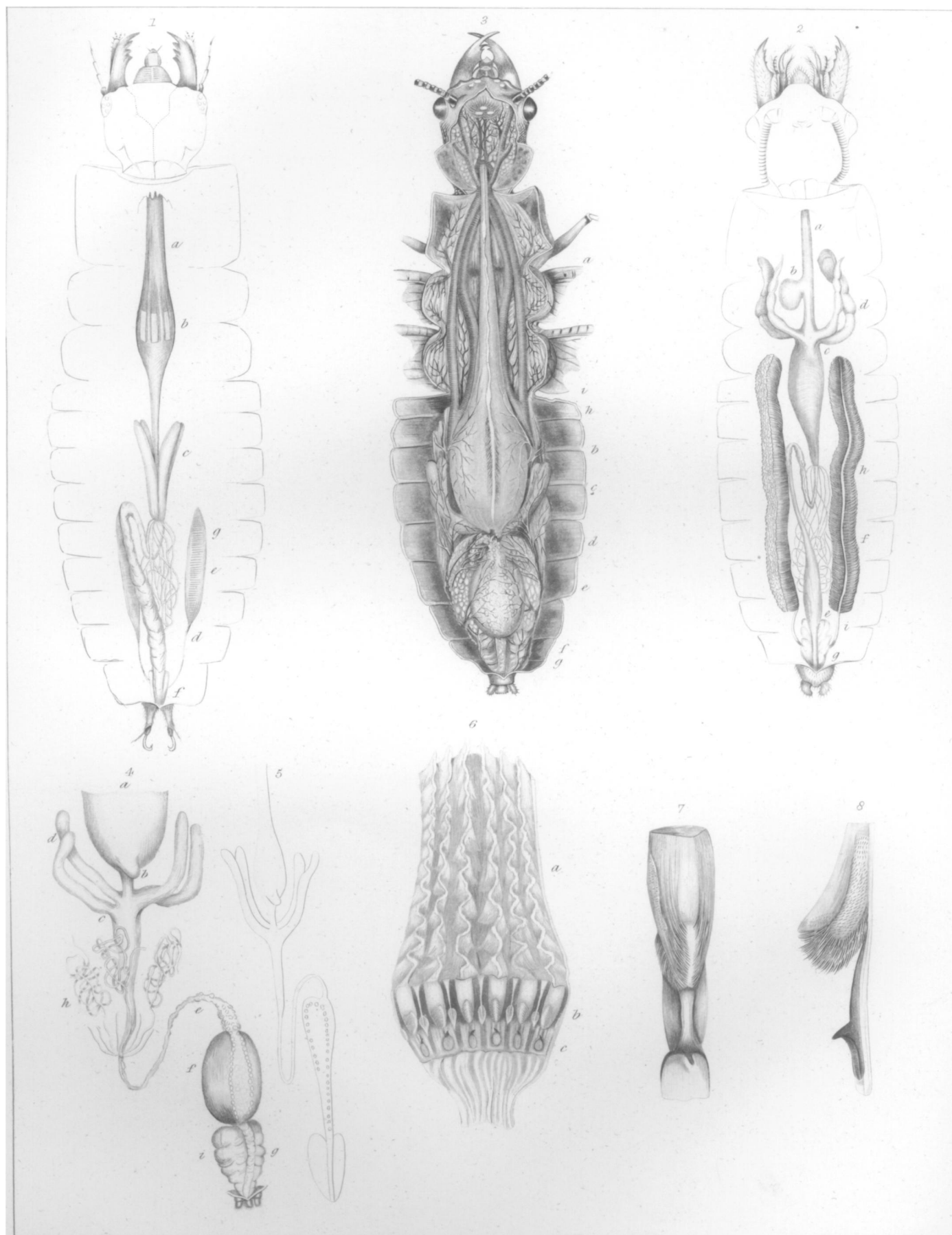
Fig. 6. Dorso-lateral view of the termination of the abdomen of the male imago, magnified two diameters, exhibiting the four prehensile hooks for attachment to the female.

Fig. 7. Ventral view of fig. 6: — *a.* generative aperture.

Fig. 8. Same view of the termination of the abdomen of the female: — *a.* generative aperture.

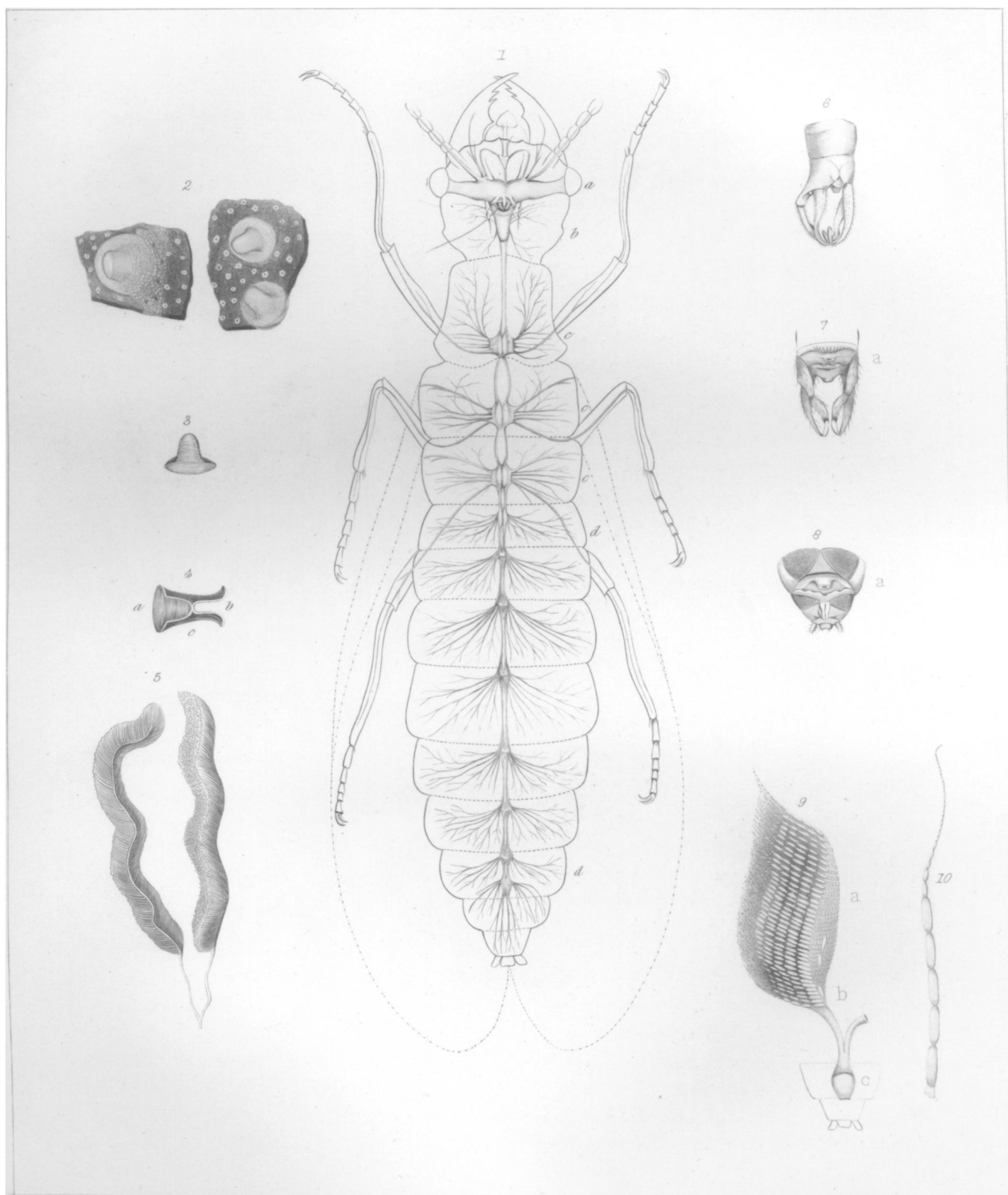
Fig. 9. Generative apparatus of the female, magnified two diameters: — *a.* ovary; *b.* oviduct; *c.* vagina.

Fig. 10. A single ovigerous tube, magnified six diameters.



Joseph Leidy, del. 1846.

ANATOMY OF CORYDALUS CORNUTUS



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